RESEARCH DEPARTMENT

Colour television systems: A note on performance figures and overall tolerances for level-dependent phase and level-dependent amplitude

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SUMMARY

A simple statistical study is made of the cumulative effects of distortion-producing errors in a television transmission. The results are applied to several colour television systems which are sensitive to errors of level-dependent phase and level-dependent amplitude.

1. INTRODUCTION

During the period 1962/1963 the Ad Hoc Colour Group of the European Broadcasting Union co-ordinated many tests and studies carried out by member organizations in order to compare three colour television systems which were competing for selection as a system for the European area. One of the many tasks accomplished by the EBU Group was a table of overall tolerances within which the distortion-producing errors must be maintained if the picture quality is not to fall below some pre-determined subjective criterion. A further table gave the performance figures to be expected from current equipment which might be used at the outset of a colour television service. These tables, with some slight modifications, now appear in an appendix to a CCIR document which constitutes the report of the 1964 special meeting of CCIR Study Group XI held in London in February 1964.

For the purposes of these tables a television system is subdivided into five major portions, each portion having ascribed to it a performance figure which amounts to a local tolerance. The two most important distortions are those resulting from level-dependent phase and level-dependent amplitude. If all the local tolerances or 'individual performance figures' for a given type of distortion be added arithmetically, their sum may exceed the overall tolerance admissible for a given quality or impairment criterion for the colour system in question. The purpose of this report is to study the probability of occurrence of such a state of affairs.

2. STATISTICAL STUDY

Annex IV, page 17, of Document 33[1] of the CCIR gives 'individual performance figures' of level-dependent phase and level-dependent amplitude for the five principal sections of a television transmission as follows:

TABLE 1

	LEVEL-DEPENDENT PHASE	LEVEL-DEPENDENT AMPLITUDE
Receiver	± 5°	10%
Transmitter	± 5°	10%
Distribution network (video section)	± 10°	8%
Studio centre ('basic unit')	± 3°	5%
Tape recorder	± 4°	20%

The same annex also gives overall tolerances for the reception of pictures having a grading of not worse than 3·5A on the one hand and not worse than 2·5A on the other hand. The meanings to be ascribed to these numbers can be found on page 19 of Document 33 and they are repeated below:

Grading

Impairment		Quality
Imperceptible	1A	Excellent
Just perceptible	2A	Good
Definitely perceptible but not disturbing	3A	Fairly good
Somewhat objectionable	4A	Rather poor
Definitely objectionable	5A	Poor
Unusable	6A	Very poor

The overall tolerances mentioned are given hereunder:

TABLE 2

	LEVEL-DEPENDENT PHASE		LEVEL-DEPENDENT AMPLITUDE	
	Grade 2·5A	Grade 3·5A	Grade 2·5A	Grade 3·5A
NTSC	± 12°	± 20°	30%	40%
SECAM	± 40°	± 50°	65%	70%
PAL_d	± 40°	± 50°	25%	40%
PAL_s	± 12°	± 20°	25%	40%

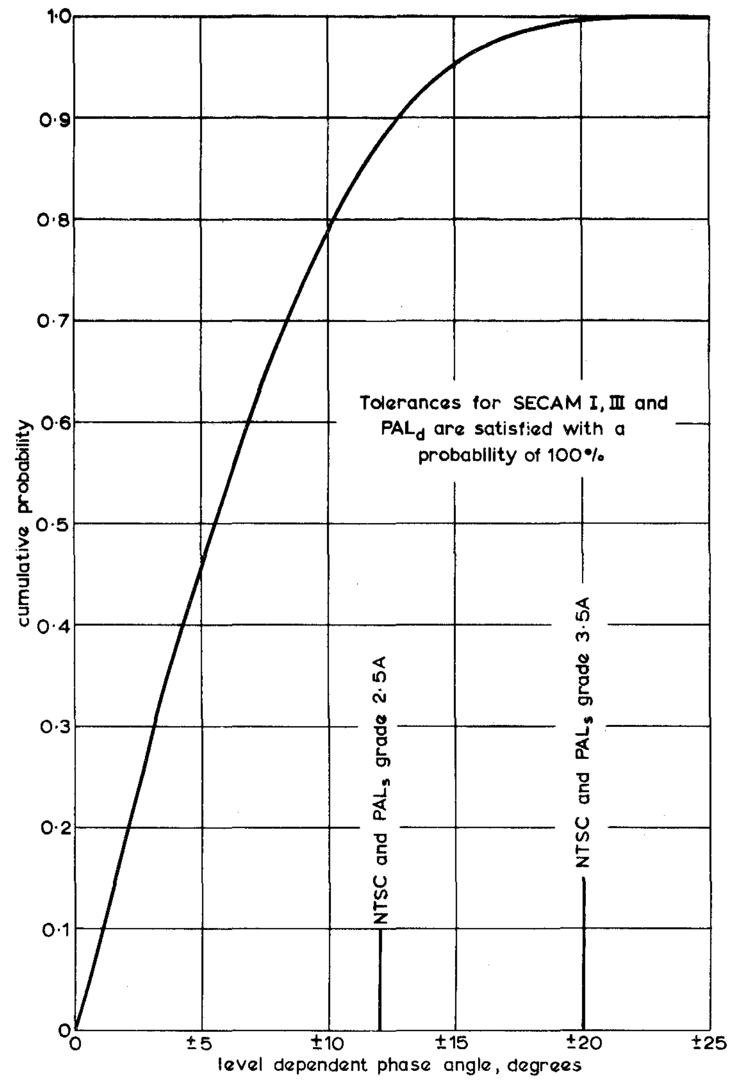


Fig. 1

Level-dependent phase

The method of calculating the figures of level-dependent amplitude is such that positive or negative signs may be ascribed to them in the same way as shown in Tables 1 and 2 with regard to level-dependent phase.

Since each portion of the television transmission can, it may be presumed, have any value of error lying between the 'individual performance figures' shown in Table 1, it seems *prima facie* reasonable to assume rectangular statistical frequency distributions for the errors of phase and amplitude for each major section of the transmission. We thus ascribe the same probability of occurrence to all errors provided they lie within the 'individual performance figures'; zero probability is assumed for all errors greater than the absolute values of the 'individual performance figures'.

The five rectangular statistical distributions resulting from each of the two types of distortion may be combined by convolution because the major elements of the transmission chain are themselves connected in tandem. The result of such convolution is to reveal the statistical frequency distribution representing the

overall statistical behaviour of errors of the complete transmission. This distribution can be compared with the overall tolerances shown in Table 2. We can then estimate how frequently or for what percentage of some suitably long time the overall tolerances are likely to be exceeded.

Fig. 1* shows the cumulative probability of occurrence of errors of level-dependent phase as a function of these errors, whilst Fig. 2* shows the similar

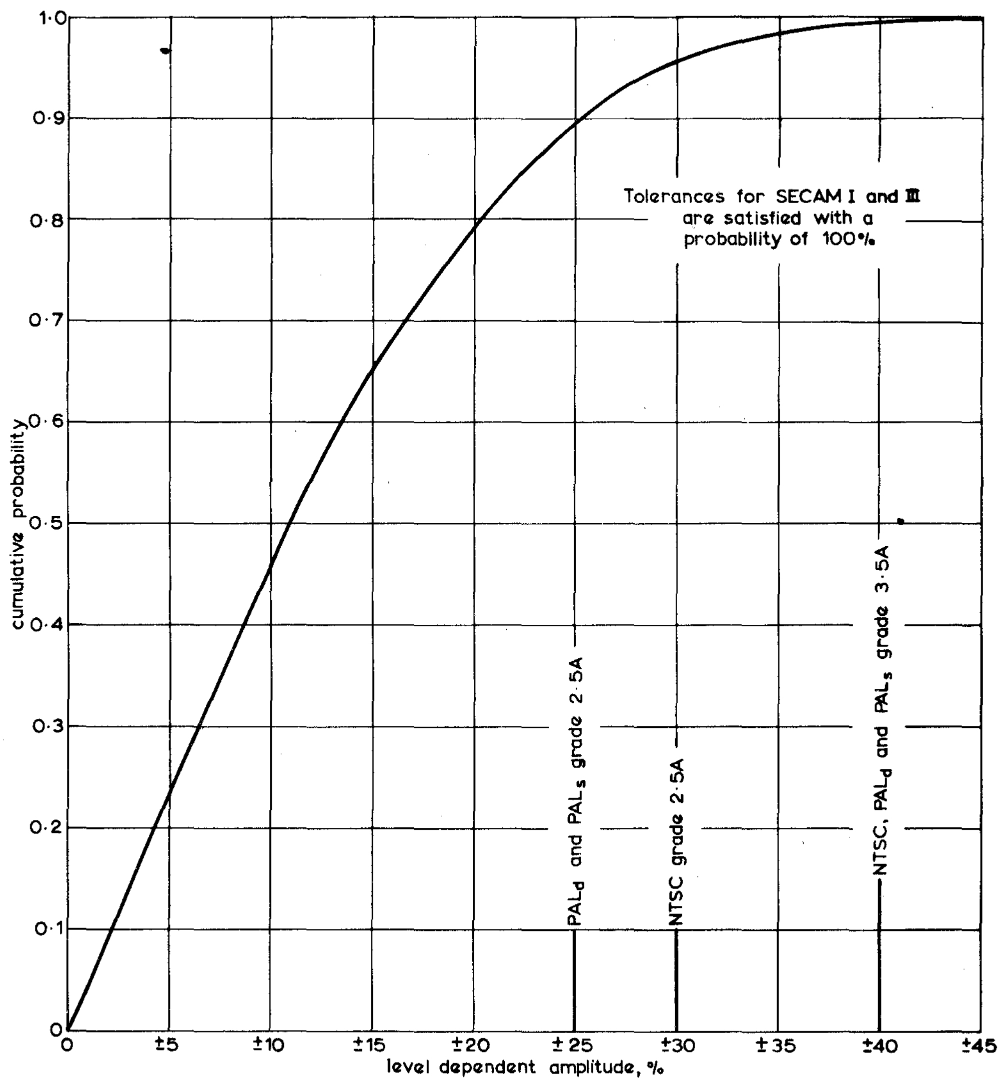


Fig. 2 - Level-dependent amplitude

function for level-dependent amplitude. The appropriate tolerances from Table 2 are shown in the two figures; thus for level-dependent phase (Fig. 1) the NTSC and PAL_s systems would exceed the tolerance for grade 2·5A pictures for 12·5% of the time and the tolerance for grade 3·5A pictures for 0·5% of the time. For level-dependent amplitude (Fig. 2) the PAL_d and PAL_s systems would exceed the tolerance

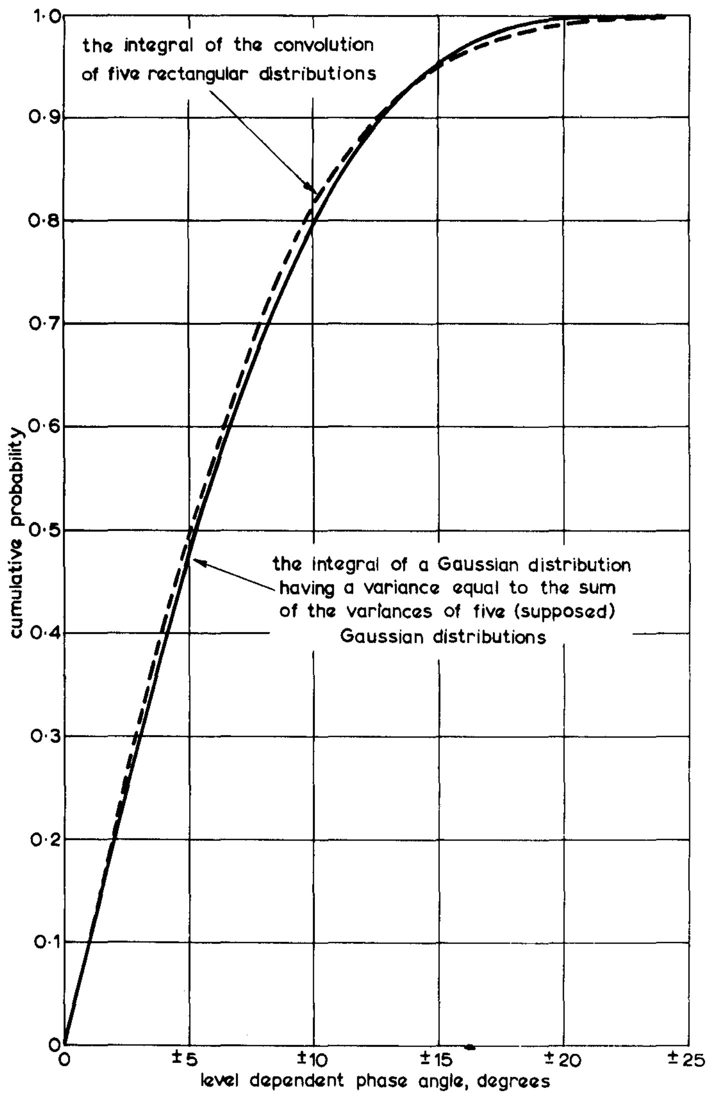
*The author is indebted to Mr. W.N. Sproson for this figure.

for grade 2·5A pictures for 10·5% of the time whilst NTSC would exceed its tolerance for grade 2·5A pictures for 4·5% of the time. The tolerance for level-dependent amplitude for grade 3·5A pictures would be exceeded by NTSC, PAL_d and PAL_s for 0·5% of the time.

It may be asked what effect would be produced upon the curves shown in Figs. 1 and 2 if, instead of rectangular statistical distributions, we had chosen Gaussian (i.e. Normal) shapes. Fig. 3 shows the cumulative curve from Fig. 1 (smooth

Fig. 3

Cumulative probability from a Gaussian distribution compared with that given by the convolution of five rectangular distributions



line) and a cumulative curve (dashed line) which is the integral of a Gaussian distribution having a variance (square of the standard deviation) equal to the sum of the variances of each separate rectangular distribution. The dashed curve may therefore be regarded as the result of assuming Gaussian distributions throughout. It will be seen that the differences which result from the two hypotheses are small. In the absence of knowledge of the real form of the statistical distributions of errors of each part of the transmission chain it therefore seems preferable to use the rectangular form since it is the simplest of all possible hypotheses.

3. CONCLUSIONS

The SECAM system presents no problem with regard to level-dependent phase nor with regard to level-dependent amplitude. Conclusions relating to the PAL and NTSC systems depend to some extent upon the quality/impairment criterion used. For grade 3·5A, no problem arises because the tolerances are exceeded for a negligibly small proportion of the time. For grade 2·5A, the conclusions must depend upon the individual judgments of each interested PTT and broadcasting authority because, as may be seen from Table 1, it is they who are responsible for four out of the five major subdivisions into which the television transmission is split.

4. REFERENCE

1. CCIR Colour Television Meeting, London 1964, Document 33 (2nd Revision), 12th March 1964.

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